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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 2, 2016/2017

### ETM2046 – ANALOG AND DIGITAL COMMUNICATIONS (BE, RE)

04 MARCH 2017  
9.00 a.m – 11.00 a.m  
(2 Hours)

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#### INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages excluding cover page with 4 questions only.
2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the answer booklet provided.

**QUESTION 1**

a) Find the trigonometric Fourier series for up to the 3<sup>rd</sup> harmonics for the function below:

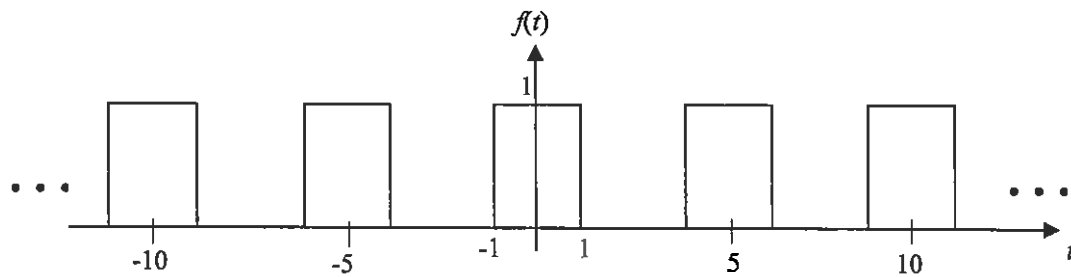


Figure Q1

[13 marks]

b) For the complex exponential Fourier series below, sketch the double sided Fourier spectra (amplitude spectrum and phase spectrum) for up to  $n=2$ .

$$x(t) = \sum_{n=-\infty}^{\infty} D_n e^{j2nt}$$

$$D_n = \frac{0.504}{1 + j4n}$$

[9 marks]

c) State three advantages of digital communications over analog communications

[3 marks]

**Continued...**

**QUESTION 2**

(a) A carrier has an amplitude of 5V and its frequency is 1MHz. It is modulated by an 8kHz signal and the modulation index is 0.6. Determine the time domain mathematical expression and sketch the single-sided frequency spectrum for:

- i) Double Sideband Large Carrier (DSB-LC) modulated signal.
- ii) Double Sideband Suppressed Carrier (DSB-SC) modulated signal.

[5+5 marks]

(b) You are given a narrow-band FM generator at a carrier frequency of 100kHz and a frequency deviation  $\Delta f = 10\text{Hz}$ ; an oscillator with an adjustable frequency in the range of 10 to 11MHz; and plenty of frequency doublers, triplers, and quintuplers. Design an Armstrong indirect FM modulator for wideband FM modulation to generate an FM carrier with a carrier frequency of 98.1MHz and frequency deviation  $\Delta f = 75\text{kHz}$ . Draw a block diagram to show your design.

[15 marks]

Continued...

**QUESTION 3**

- (a) A Delta Modulation (DM) system is designed to modulate audio signals of up to 3400Hz. In a specific process, a signal

$$x(t) = \cos(1400\pi t) + \cos(500\pi t)$$

is sampled at a rate of 128 kHz.

- i) Determine the minimum value of the step size  $\Delta$  to avoid slope overload. [5 marks]
  - ii) Determine the granular-noise power  $N_o$ . [3 marks]
- (b) Explain how intersymbol interference (ISI) arises in bandlimited digital signals, and how it affects the system performance. [2+2 marks]
- (c) State the advantage and disadvantage of unipolar NRZ signalling over polar NRZ signaling. [2+2marks]
- (d) Given a PCM binary data 10011101. Sketch the corresponding signalling line code waveforms of the PCM binary data using:
- i) Unipolar NRZ
  - ii) Polar NRZ
  - iii) Unipolar RZ
  - iv) Manchester NRZ

Which signaling code has the largest transmission bandwidth?

[8+1 marks]

**Continued...**

**QUESTION 4**

- (a) A discrete memoryless source has an alphabet of five symbols whose probabilities of occurrence are as described below.

$$P(S_0)=0.45, \quad P(S_1)=0.22, \quad P(S_2)=0.14, \quad P(S_3)=0.10, \quad P(S_4)=0.09$$

- i) Construct the Huffman code for this source. [9 marks]
  - ii) Compute the average Huffman codeword length,  $L$ . [3 marks]
  - iii) Calculate the entropy of the source,  $H$ . [3 marks]
- (b) A computer keyboard can generate 110 different characters. Each character is sent in a codeword over an additive white Gaussian noise (AWGN) channel, which has a bandwidth of 3.2 kHz and signal-to-noise ratio (SNR) of 20dB
- i) Determine the number of bits required to code each character? [3 marks]
  - ii) How many characters can be transmitted in one second to achieve small error probability? [3 marks]
  - iii) If each character is equally likely to be sent, find the information content per character [4 marks]

**Continued...**

**Appendix I: Table of Bessel Function**

$\beta \backslash n$	0.05	0.1	0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	7.0	8.0	10.0
0	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178	0.300	0.172	-0.246
1	0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2		0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3				0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4						0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5								0.007	0.043	0.261	0.348	0.186	-0.234
6								0.001	0.011	0.131	0.339	0.338	-0.014
7									0.003	0.053	0.234	0.321	0.217
8										0.018	0.128	0.223	0.318
9										0.006	0.059	0.126	0.292
10										0.001	0.024	0.061	0.208
11											0.008	0.026	0.123
12											0.003	0.010	0.063
13											0.001	0.003	0.029
14												0.001	0.012
15													0.005
16													0.002
17													0.001

**Appendix II: Table of Trigonometric Identities**

$$\sin A \sin B = \frac{1}{2} [\cos(A - B) - \cos(A + B)]$$

$$\cos A \cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$$

$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A + B) = \cos A \cos B - \sin A \sin B$$

$$\sin \theta = \frac{1}{2j} [e^{j\theta} - e^{-j\theta}]$$

$$\cos \theta = \frac{1}{2} [e^{j\theta} + e^{-j\theta}]$$

Continued...

**Appendix III: Fourier Transform Pairs**

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t - t_o)$	$e^{-j2\pi f t_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f - f_o)$
$e^{-at}u(t)$	$\frac{1}{a + j2\pi f}$ , for $a > 0$
$e^{at}u(-t)$	$\frac{1}{a - j2\pi f}$ , for $a > 0$
$e^{-a t }$	$\frac{2a}{a^2 + (2\pi f)^2}$ , for $a > 0$
$\text{rect}\left(\frac{t}{T}\right)$	$T \text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W} \text{rect}\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2} \text{sinc}^2\left(\frac{fT}{2}\right)$
$W \text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2} \delta(f - f_o) + \frac{1}{2} \delta(f + f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j} [\delta(f - f_o) - \delta(f + f_o)]$

Continued...

**Appendix IV: Fourier Transform Properties**

Let $x(t) \Leftrightarrow X(f)$ , $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$ ; and $a, b, t_o$ and $f_o$ scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Scaling ( $a \neq 0$ )	$x(at) \Leftrightarrow \frac{1}{ a } X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n} x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n} X(f)$
Time Integration	$\int_{-\infty}^t x(\tilde{t}) d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f} + \frac{1}{2} X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^f X(\tilde{f}) d\tilde{f}$

**End of Paper**